```
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%EC401 Lab 6
%U29407369
```

Lab 6.1

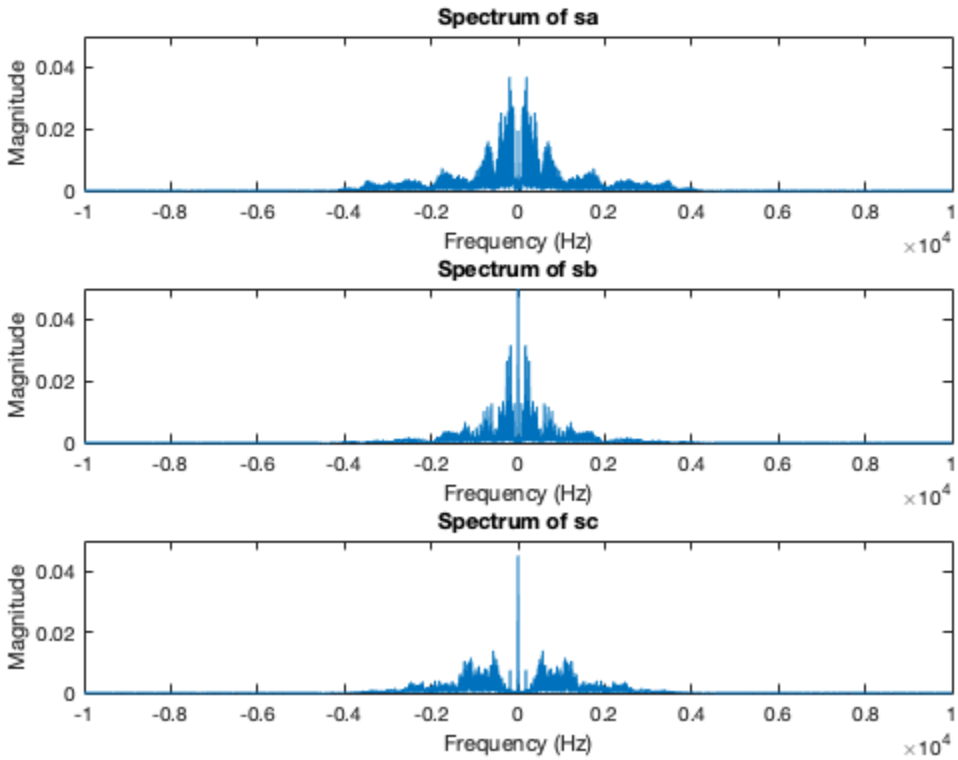
```
%a.)
cd("/Users/melissaregalado/Documents/MATLAB/EC401/Lab 6")
load signals;
figure(1);
signals = {sa, sb, sc};
titles = {'Spectrum of sa', 'Spectrum of sb', 'Spectrum of sc'};

for i = 1:length(signals)
    [S, f] = ctft(signals{i}, Fs);
    subplot(3, 1, i);
    plot(f, abs(S));
    xlabel('Frequency (Hz)');
    ylabel('Magnitude');
    title(titles{i});
    axis([-10000 10000 0 0.05]);
    sound(resample(signals{i}, Fslinux, Fs), Fslinux);
    pause(5);
end

%b.)

fa = 50000;
fb = 60000;
fc = 70000;

t = (0:1/Fs:(length(sa) - 1)/Fs)';

ya = sa .* cos(2 * pi * fa * t);
yb = sb .* cos(2 * pi * fb * t);
yc = sc .* cos(2 * pi * fc * t);

figure(2);
mod_signals = {ya, yb, yc};
mod_titles = {'Spectrum of ya', 'Spectrum of yb', 'Spectrum of yc'};

for i = 1:length(mod_signals)
    [Y, f] = ctft(mod_signals{i}, Fs);
    subplot(3, 1, i);
    plot(f, abs(Y));
    xlabel('Frequency (Hz)');
    ylabel('Magnitude');
    title(mod_titles{i});
end

%c.)
```

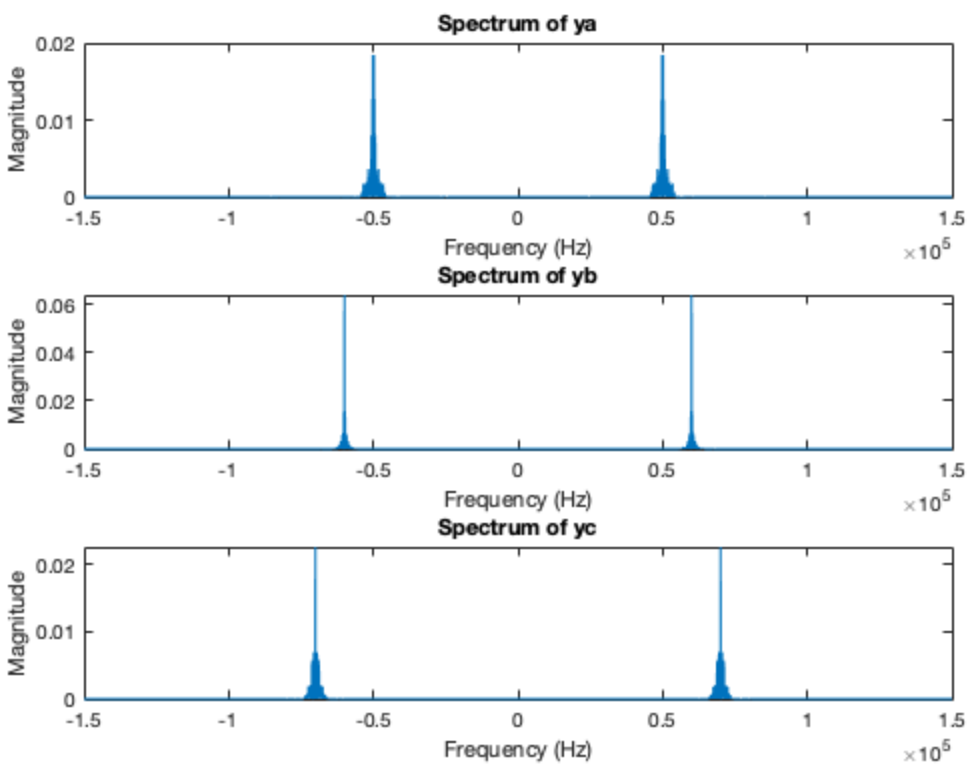
```
w = ya + yb + yc;

figure(3);
[W, f] = ctft(w, Fs);
plot(f, abs(W));
xlabel('Frequency (Hz)');
ylabel('Magnitude');
title('Spectrum of the multiplexed signal (w)');
axis([40000 80000 0 0.05]);

% there's distinct overlapping spectra each with its 5khz bandwidth
%in modulated and combined

t0 = 3;
Dur = 5 / 4000;
I = find(t0 < t & t < (t0 + Dur));
figure(4);
plot(t(I), sa(I), 'r', t(I), ya(I));
xlabel('t (sec)');
ylabel('Amplitude');
title('Time-domain comparison: sa(t) and ya(t)');
legend('sa', 'ya', 'Location', 'Best');

% ya(t) oscillates fast w amplitude that resembles original sa(t)

% b.)

fc = 5000;
Ncross = 40;
Fs = 200000;

tf = -Ncross/(2*fc):1/Fs:+Ncross/(2*fc);
h = (2 * fc) * sinc(2 * fc * tf);
h = 2 * h;

% FFT of the impulse response h and shifts the
% zero-frequency (DC) component to the center

H = fftshift(fft(h, 1024));

%requency axis aligned with the shifted FFT output,
frequencies = fftshift((0:1023) / 1024 * Fs - Fs/2);

titles = {'Impulse Response of Lowpass Filter', 'Frequency Response of
Lowpass Filter'};
x_labels = {'Time (s)', 'Frequency (Hz)'};
y_labels = {'Amplitude', 'Magnitude'};
data_x = {tf, frequencies};
data_y = {h, abs(H)};

figure(5);
for i = 1:2
    subplot(2, 1, i);
    plot(data_x{i}, data_y{i});
```

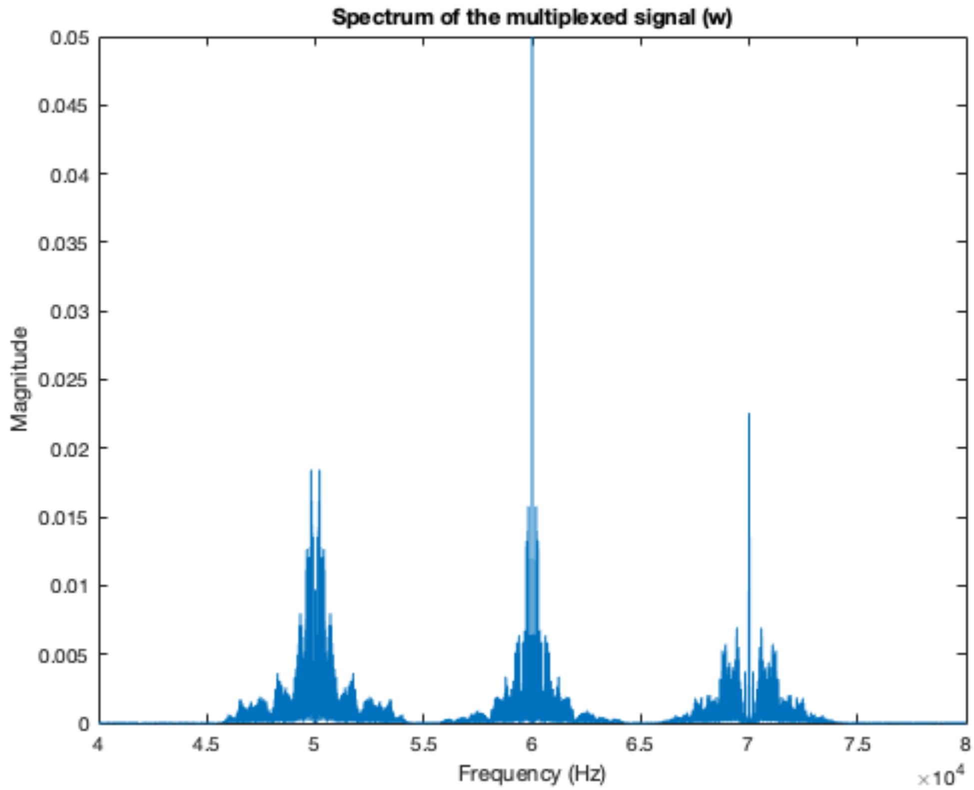
```
    title(titles{i});
    xlabel(x_labels{i});
    ylabel(y_labels{i});
end

% used chat gpt to debug because the plots wouldnt show up
% the values seemed wrong/not appearing
% disp(['Frequency Axis Range: ', num2str(min(frequencies)), ' to ',
num2str(max(frequencies))]);
% disp(['FFT Resolution: ', num2str(Fs / 1024), ' Hz']);
% disp(['Max |H|: ', num2str(max(abs(H)))]);
% disp(['Min |H|: ', num2str(min(abs(H)))]);

% c.)

% fd = fa;
% t = (0:1/Fs:(length(w) - 1)/Fs)';
%
% z = w .* cos(2 * pi * fd * t);
% rd = conv(z, h) / Fs;
%
% [Z, f_z] = ctft(z, Fs);
% [RD, f_rd] = ctft(rd, Fs);
%
% % disp(['Size of f: ', num2str(size(f))]);
% % disp(['Size of data{i}: ', num2str(size(data{i}))]);
%
% % this is to adjust sizes since i was using for loops :(
%
% min_len_z = min(length(f_z), length(Z));
% f_z = f_z(1:min_len_z);
% Z = Z(1:min_len_z);
%
% min_len_rd = min(length(f_rd), length(RD));
% f_rd = f_rd(1:min_len_rd);
% RD = RD(1:min_len_rd);
%
%
% frequencies = {f_z, f_rd};
% data = {abs(Z), abs(RD)};
%
% titles = {'Spectrum of Demodulated Signal z', 'Spectrum of Recovered Signal
rd'};
% x_labels = {'Frequency (Hz)', 'Frequency (Hz)'};
% y_labels = {'Magnitude', 'Magnitude'};
%
%
% figure(6);
% for i = 1:2
%     % Ensure matching sizes between frequency and data
%     min_len = min(length(frequencies{i}), length(data{i}));
%     freq = frequencies{i}(1:min_len);
%     spectrum = data{i}(1:min_len);
%
```

```
%     subplot(2, 1, i);
%     plot(freq, spectrum);
%     title(titles{i});
%     xlabel(x_labels{i});
%     ylabel(y_labels{i});
% end
%
% sound(resample(rd, Fslinux, Fs), Fslinux);
% modified code to work for all 3,

carrier_frequencies = [fa, fb, fc];
titles = {
    'Spectrum of Demodulated Signal (Station A)', 'Spectrum of Recovered
Signal (Station A)', ...
    'Spectrum of Demodulated Signal (Station B)', 'Spectrum of Recovered
Signal (Station B)', ...
    'Spectrum of Demodulated Signal (Station C)', 'Spectrum of Recovered
Signal (Station C)'
};

figure(6);
rd_all = cell(1, 3);
%station_idx = 0;


for station_idx = 1:3
    fd = carrier_frequencies(station_idx);
    t = (0:1/Fs:(length(w) - 1)/Fs)';

    z = w .* cos(2 * pi * fd * t);
    rd = conv(z, h) / Fs;

    rd_all{station_idx} = rd;


    [Z, f_z] = ctft(z, Fs);
    [RD, f_rd] = ctft(rd, Fs);

    min_len_z = min(length(f_z), length(Z));
    f_z = f_z(1:min_len_z);
    Z = Z(1:min_len_z);

    min_len_rd = min(length(f_rd), length(RD));
    f_rd = f_rd(1:min_len_rd);
    RD = RD(1:min_len_rd);

    subplot(3, 2, (station_idx - 1) * 2 + 1);
    plot(f_z, abs(Z));
    title(titles{(station_idx - 1) * 2 + 1});
    xlabel('Frequency (Hz)');
    ylabel('Magnitude');

    subplot(3, 2, (station_idx - 1) * 2 + 2);
    plot(f_rd, abs(RD));
```

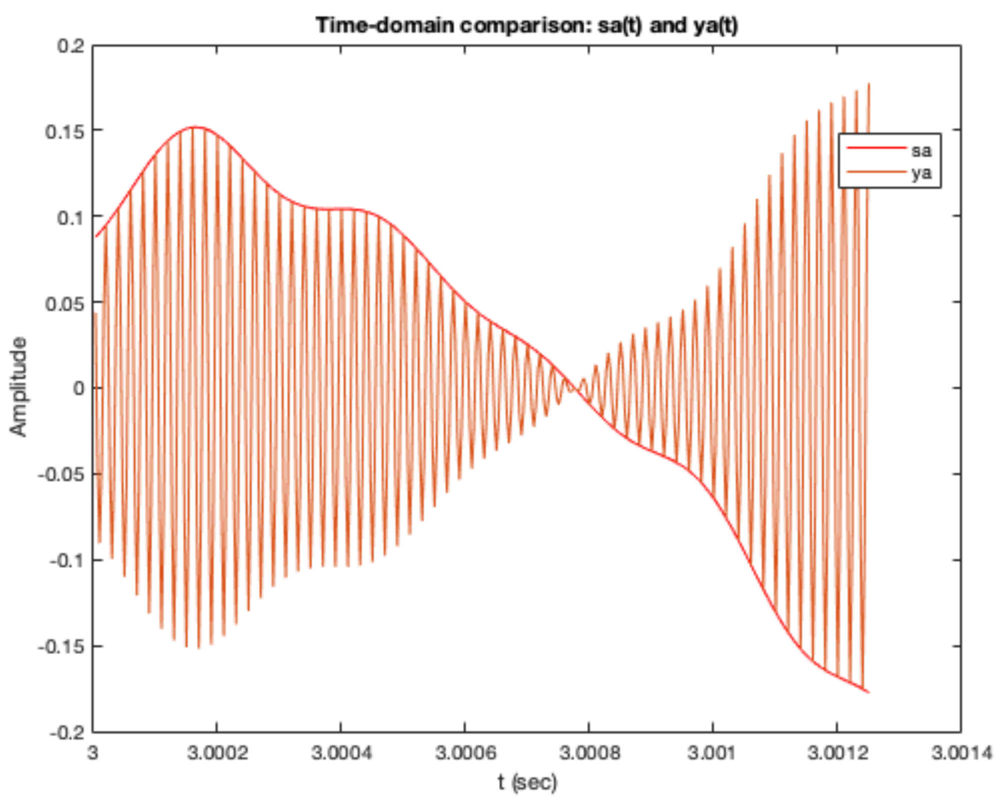
```
    title(titles{(station_idx - 1) * 2 + 2});
    xlabel('Frequency (Hz)');
    ylabel('Magnitude');
end

for i = 1:3
    recovered_signal = rd_all{i};
    sound(resample(recovered_signal, Fslinux, Fs), Fslinux);
    pause(8);
end

% d.)

fd = 0.8 * fa + 0.2 * fb;
t = (0:1/Fs:(length(w) - 1)/Fs)';

z = w .* cos(2 * pi * fd * t);
rd = conv(z, h) / Fs;

[Z, f_z] = ctft(z, Fs);
[RD, f_rd] = ctft(rd, Fs);

min_len_z = min(length(f_z), length(Z));
f_z = f_z(1:min_len_z);
Z = Z(1:min_len_z);

min_len_rd = min(length(f_rd), length(RD));
f_rd = f_rd(1:min_len_rd);
RD = RD(1:min_len_rd);

figure(7);
subplot(2, 1, 1);
plot(f_z, abs(Z));
title('Spectrum of Demodulated Signal with Incorrect Tuning');
xlabel('Frequency (Hz)');
ylabel('Magnitude');

subplot(2, 1, 2);
plot(f_rd, abs(RD));
title('Spectrum of Recovered Signal with Incorrect Tuning');
xlabel('Frequency (Hz)');
ylabel('Magnitude');

sound(resample(rd, Fslinux, Fs), Fslinux);

% sound just sounds fainter/distorted and on plot bandiwidth mangnitude are
lower
% displaying more interference.
```


Spectrum of sa
Magnitude
Frequency (Hz)
Spectrum of sb
Magnitude
Frequency (Hz)
Spectrum of sc
Magnitude
Frequency (Hz)


Spectrum of ya
Magnitude
Frequency (Hz)
Spectrum of yb
Magnitude
Frequency (Hz)
Spectrum of yc
Magnitude
Frequency (Hz)



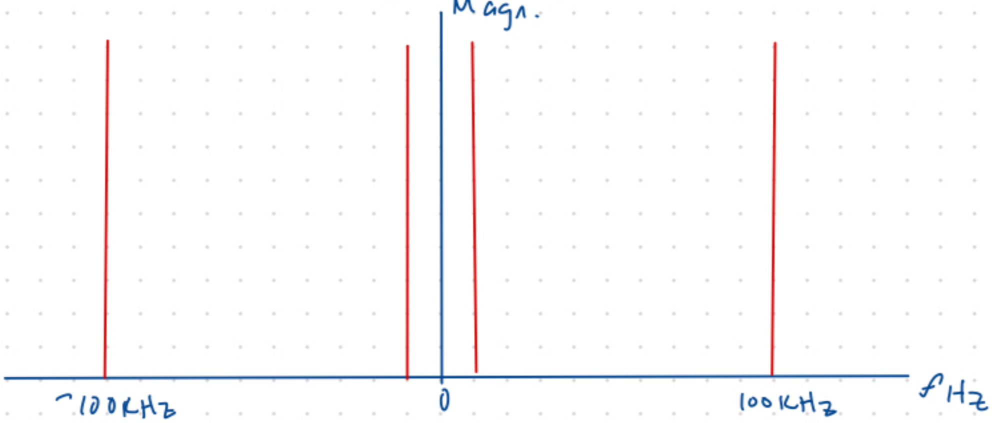
Spectrum of the multiplexed signal (w)
0.05
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
Magnitude
4
4.5
5
5.5
6
6.5
7
7.5
8
Frequency (Hz)
$\times10^4$



Time-domain comparison: sa(t) and ya(t)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
Amplitude
sa
ya
3
3.0002
3.0004
3.0006
3.0008
3.001
3.0012
3.0014
t (sec)

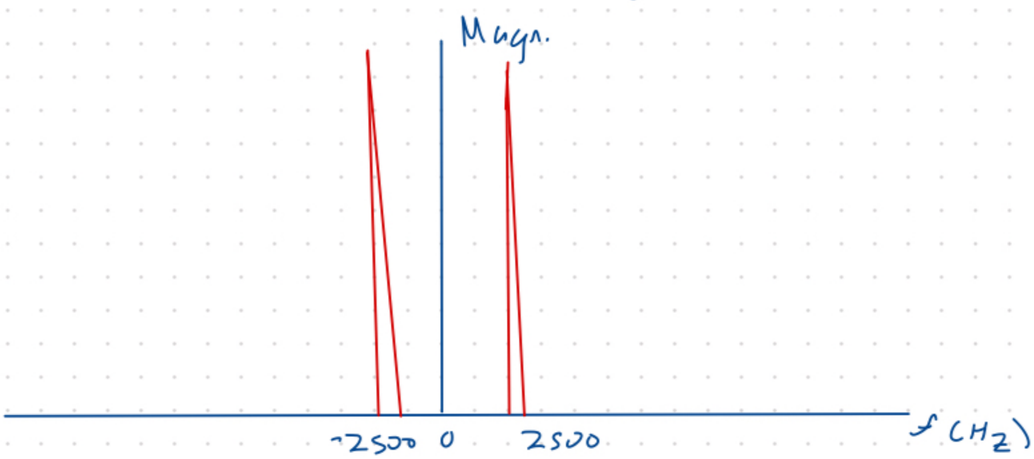
Lab 6.2

a.) Demodulated Signal $Z(j2\pi f)$



↑ $f_d = f_a = 50KHz$ which is now $2f_a = \pm 100KHz$

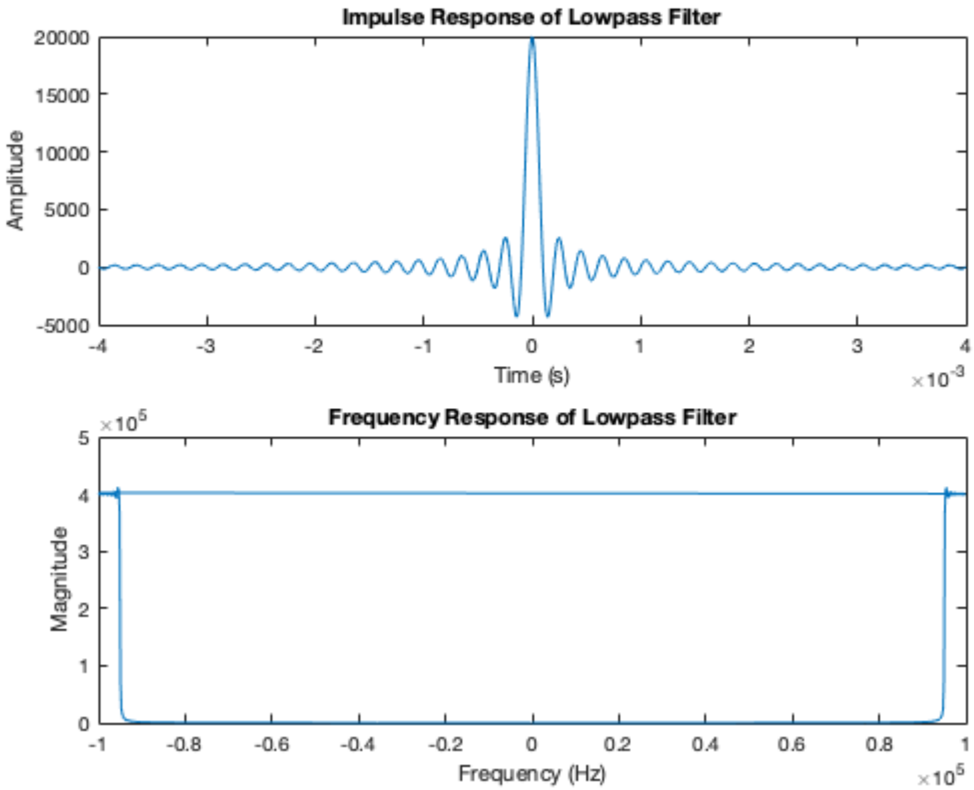
Spectrum recovered $R_d(j2\pi f)$

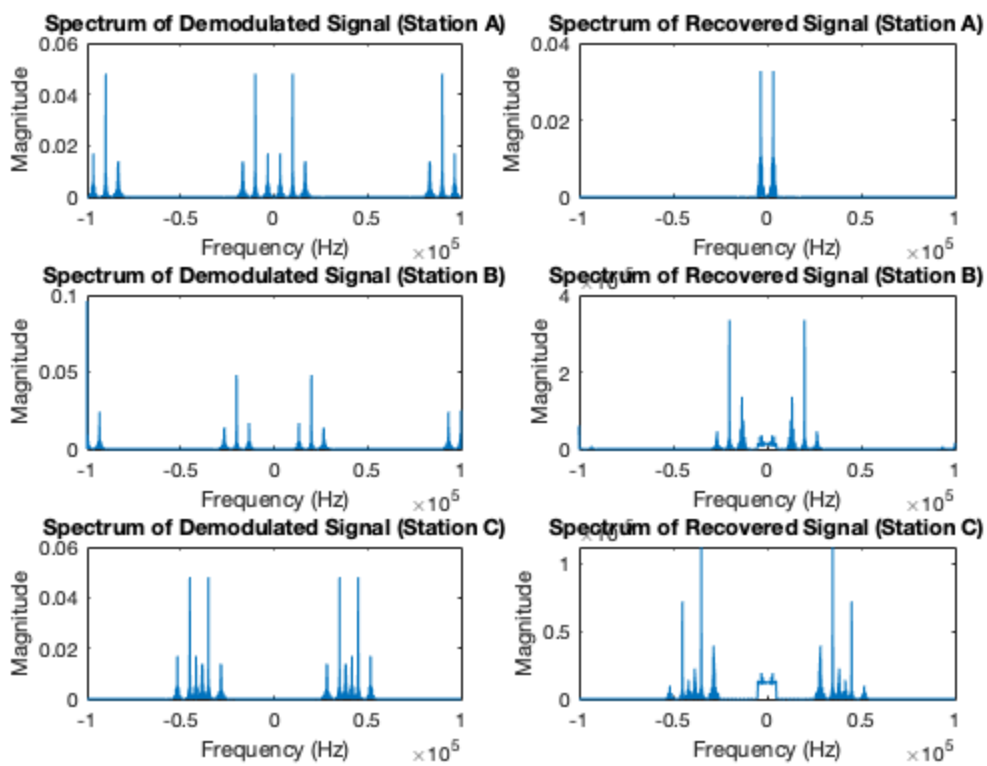


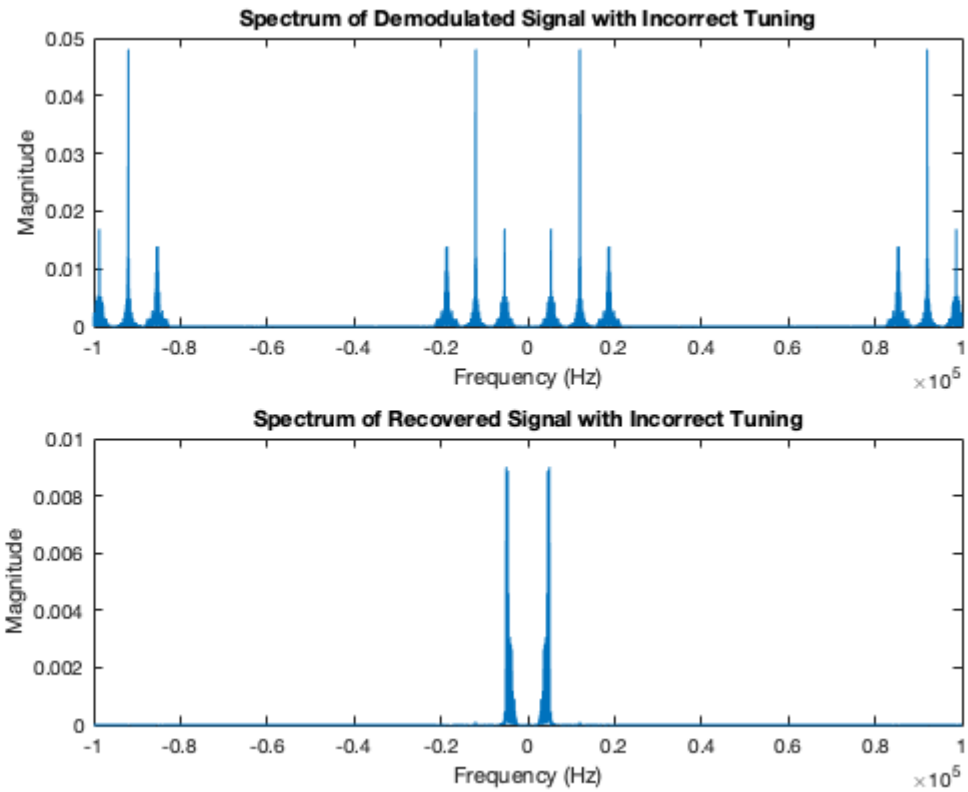
↑ bandwith of 5KHz; This recovered signal.

Spectra is desired signal sa. Lowpass fiter would remove artifacts and focus on signal around 0Hz

0 Hz, ± 100 KHz


Impulse Response of Lowpass Filter
Amplitude
Time (s)
×10^-3
Frequency Response of Lowpass Filter
×10^5
Magnitude
Frequency (Hz)
×10^5


Spectrum of Demodulated Signal (Station A)
Spectrum of Recovered Signal (Station A)
Spectrum of Demodulated Signal (Station B)
Spectrum of Recovered Signal (Station B)
Spectrum of Demodulated Signal (Station C)
Spectrum of Recovered Signal (Station C)
Magnitude
Frequency (Hz)
×10^5



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